10 Material budget

As already emphasized many times the performance of the TRD will crucially depend on its overall radiation thickness. In Table 10.1 we summarize the radiation thickness of all components in the active area of the detector. In the simulations (see Chapters 6,11,and 12) also detector material outside the active area has been considered to properly account for the induced background due to structural elements and other detectors of the central barrel.

Table 10.1: Material budget of the TRD. Only components contributing within the detector's active area are listed.

Element	Material	X/X_0 [%] at $\eta = 0$
radiator	G10/Rohacell/fiber	0.93
radiator gas	air	0.02
drift electrode	metallized Mylar	0.02
drift chamber gas	Xe/CO_2	0.24
pad plane	G10/Cu	0.13
foam backing	Rohacell	0.18
stiffening fibers	carbon fiber	0.09
readout motherboards	G10/Cu	0.44
multichip module	G10/Si/epoxy	0.14
cooling	H_2O/Al	0.20
1 TRD module		2.39
full TRD		14.34

The total radiation thickness of the radiator includes all components listed for the S-HF71 sandwich radiator with reinforcement as listed in Table 3.1 of Chapter 3. In the material budget of the radiator gas the air gap between consecutive layers of the TRD was also included. If the surfaces of the laminated radiator foam are very smooth, it may be possible to reduce the thickness of the drift electrode somewhat (it has been included assuming a thickness of 50 μm).

For the drift chamber gas, Xe/CO_2 (85/15) with a total thickness of 37 mm has been considered. The padplane is included with a thickness of 250 μm and a copper coating of 5μm. The pad planes are supported by a Rohacell® HF31 foam backing. The backing itself is reinforced by glueing carbon fiber rods with a diameter of 1.8 mm into groves with a regular spacing of 1.5 cm. Averaging the material of the carbon fibers over the detector surface, this is equivalent to a homogeneous layer of 200 μm thickness. The readout motherboards will be 4-layer printed circuit boards of 400 μm thickness. Two layers will be used for power and ground. Both of these layers will have an areal coverage of copper of 20% each. The other two layers will be signal layers with a coverage of copper of 30% each. It is foreseen to use a standard multilayer printed circuit board here, so the copper thickness is 34μm. Passive components such as small chip capacitors for decoupling and storage, voltage regulators, the PAROLI link, and the TTCrx chip have not been considered. However, they should only contribute a very moderate and localized increase in the overall radiation length.

The multichip modules will be implemented as ball grid arrays (BGA). The size of them will be below 10 cm^2. They cover only about 10% of the active area. The radiation length quoted is averaged over the detector area. In the estimate of the radiation length of such a modules the chip carrier(G10), the silicon wafers, their glob top, and the solder balls were included. The mulitchip modules will be actively cooled as outlined in Chapter 9. The individual cooling pads will be thin aluminum panels

(1mm) in thermal contact with an aluminum pipe of 2 mm diameter filled with water. The areal coverage corresponds to about 12% of the active area.